PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : G06F 17/22 — A1

(11) International Publication Number: **WO 98/19253**

(43) International Publication Date: 7 May 1998 (07.05.98)

(21) International Application Number: PCT/US97/19362

(22) International Filing Date: 28 October 1997 (28.10.97)

(30) Priority Data:
08/738,889 28 October 1996 (28.10.96) US

(71) Applicant: TRUSTEES OF COLUMBIA UNIVERSITY IN THE CITY OF NEW YORK [US/US]; 116th Street and Broadway, New York, NY 10027 (US).

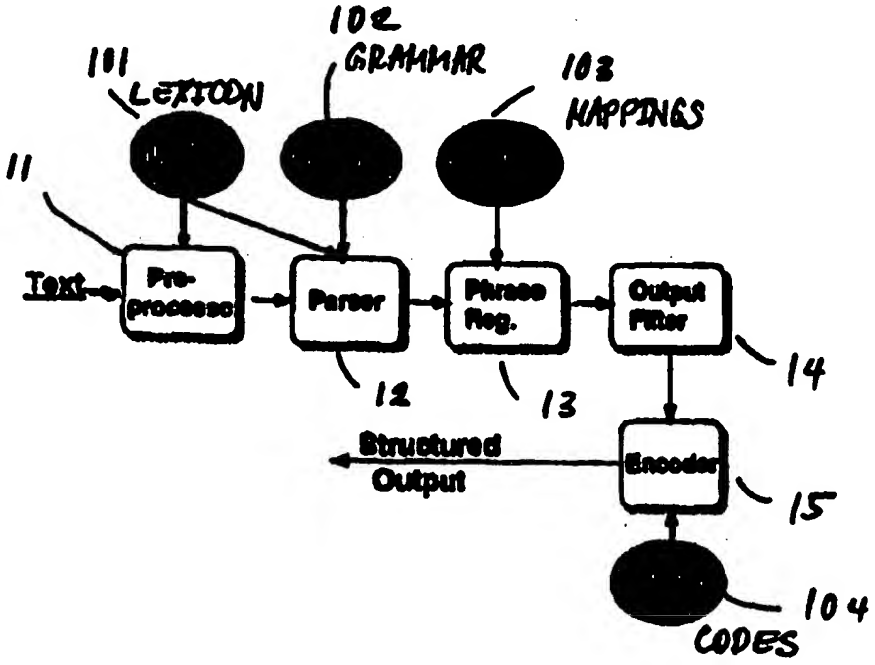
(72) Inventor: FRIEDMAN, Carol; 14 Dimitri Place, Larchmont, NY 10538 (US).

(74) Agents: TANG, Henry et al.; Brumbaugh, Graves, Donohue & Raymond, 30 Rockefeller Plaza, New York, NY 10112-0228 (US).

(81) Designated States: CA, JP, European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: SYSTEM AND METHOD FOR MEDICAL LANGUAGE EXTRACTION AND ENCODING



(57) Abstract

In computerized processing of natural-language medical/clinical data including phrase parsing and regularizing, parameters are referred to whose values can be specified by the user. Thus, a computerized system can be provided with versatility, for the processing of the data originating in diverse domains, for example. Further to a parser (12) and a regularizer (13), the system includes a preprocessor (11), output filters (14) and an encoding mechanism (15).

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece			TR	Turkey
BG	Bulgaria	HU	Hungary	ML	Mali	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MN	Mongolia	UA	Ukraine
BR	Brazil	IL	Israel	MR	Mauritania	UG	Uganda
BY	Belarus	IS	Iceland	MW	Malawi	US	United States of America
CA	Canada	IT	Italy	MX	Mexico	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NE	Niger	VN	Viet Nam
CG	Congo	KE	Kenya	NL	Netherlands	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NO	Norway	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	NZ	New Zealand		
CM	Cameroon			PL	Poland		
CN	China	KR	Republic of Korea	PT	Portugal		
CU	Cuba	KZ	Kazakstan	RO	Romania		
CZ	Czech Republic	LC	Saint Lucia	RU	Russian Federation		
DE	Germany	LI	Liechtenstein	SD	Sudan		
DK	Denmark	LK	Sri Lanka	SE	Sweden		
EE	Estonia	LR	Liberia	SG	Singapore		

Description

System and Method for Medical Language Extraction and Encoding

Background of the Invention

This invention relates to natural language processing and, more specifically, to computerized processing of natural-language phrases found in medical/clinical data.

Clinical information as expressed by health care personnel is typically provided in natural language, e.g., in English. But, while phrases in natural language are convenient in interpersonal communication, the same typically does not apply to computerized applications such as automated quality assurance, clinical decision support, patient management, outcome studies, administration, research and literature searching. Even where clinical data is available in electronic or computer-readable form, the data may remain inaccessible to computerized systems because of its form as narrative text.

For computerized applications, methods and systems have been developed for producing standardized, encoded representations of clinical information from natural-language sources such as findings from examinations, medical history, progress notes, and discharge summaries. Special-purpose techniques have been used in different domains, e.g., general and specialized pathology, radiology, and surgery discharge reports.

Of particular further interest is a general approach which is based on concepts and techniques described in the following papers:

C. Friedman et al., "A Conceptual Model for Clinical Radiology Reports". In: C. Safran, ed., Seventeenth Symposium for Computer Applications in Medical Care, New York, McGraw-Hill, March 1994, pp. 829-833;

C. Friedman et al., "A General Natural-Language Text Processor for Clinical Radiology", Journal of the American Medical Informatics Association, Vol. 1 (April 1994), pp. 161-174;

C. Friedman et al., "A Schema for Representing Medical Language Applied to Clinical Radiology", Journal of the American Medical Informatics Association, Vol. 1 (June 1994), pp. 233-248;

C. Friedman et al., "Natural Language Processing in an Operational Clinical Information System", Natural Language Engineering, Vol. 1 (March 1995), pp. 83-106.

Summary of the Invention

A preferred method for computerized processing of natural-language medical/clinical data includes basic steps here designated as phrase parsing and regularizing and, optionally, code selection. Further included, preferably, is a step of pre-processing prior to phrase parsing, and a step of output filtering. Output can be generated in the form of a printout, as a monitor display, as a database entry, or via the "information highway", for example.

In processing, one or several parameters are referred to. The parameters are associated with options. To choose an option, the appropriate value is assigned to the parameter. A parameter can have a value by default. Of particular importance is the inclusion of a parameter which is associated with the medical/clinical domain or subfield of the input data. Other parameters may be associated with the level of parsing accuracy desired, whether code selection is desired, the type of filtering, or the format of the output.

The method can be expressed in a high-level computer language such as Prolog, for example, for execution as a system on a suitable general-purpose computer. In the following, the method and the system will be referred to by the acronym MedLEE, short for Medical Language Extraction and Encoding.

Brief Description of the Drawing

Fig. 1 is a diagram of the MedLEE system or "server".

Fig. 2 is a diagram of a system or application which has an interface for MedLee.

An Appendix hereto includes a printout of computer source code for a portion of MedLEE.

Detailed Description of Preferred Embodiments

A natural-language phrase included in medical/clinical data is understood as a delimited string comprising natural-language terms or words. The string is computer-readable as obtained, e.g., from a pre-existing database, or from keyboard input, optical scanning of typed or handwritten text, or processed voice input. The delimiter may be a period, a semicolon, an end-of-message signal, a new-paragraph signal, or any other suitable symbol recognizable for this purpose. Within the phrase, the terms are separated by another delimiter, e.g., a blank or another suitable symbol.

As a result of phrase parsing, terms in a natural-language phrase are classified, e.g., as referring to a body part, a body location, a clinical condition or a degree of certainty of a clinical condition, and the relationships between the terms are established and represented in a standard form. For example, in the phrase "moderate cardiac enlargement", "moderate" is related to "enlargement" and cardiac is also related to "enlargement".

In the interest of versatility and applicability of the system to different domains, parsing is domain specific as a function of the value assigned to a parameter which the system refers to in parsing. Depending on the value of the domain parameter, the appropriate rules can be referred to in parsing by the system.

While parsing may be based primarily on semantics or meaning, use of syntactic or grammatical information is not precluded.

Regularizing involves bringing together terms which may be discontiguous in a natural-language phrase but which belong together conceptually. Regular forms or composites are obtained. Regularizing may involve reference to a separate knowledge base. For example, from each of the phrases "heart is enlarged",

"enlarged heart", "heart shows enlargement" and "cardiac enlargement", a regularizer can generate "enlarged heart".

In code selection, which is optional, a common, unique vocabulary term or code is assigned to each regular term by reference to yet another knowledge base which may also be chosen domain specific. For example, in the domain of X-ray diagnostics, the term "cystic disease" has a different meaning as compared with the domain of mammography.

Fig. 1 shows a preprocessor module 11 by which natural-language input text is received. The preprocessor uses the lexicon knowledge base 101 and handles abbreviations, which may be domain dependent. With the domain parameter properly set, the preprocessor refers to the proper knowledge base. For example, depending on the domain, the abbreviation "P.E." can be understood as physical examination or as pleural effusion. Also, the preprocessor determines phrase or sentence boundaries, and generates a list form for each phrase for further processing by the parser module 12.

The parser module 12 also uses the lexicon 101, and a grammar module 102 to generate intermediate target forms. Thus, in addition to parsing of complete phrases, subphrase parsing can be used to advantage where highest accuracy is not required. In case a phrase cannot be parsed in its entirety, one or several attempts can be made to parse a portion of the phrase for obtaining useful information in spite of some uncertainty. For example, subphrase parsing can be used in surveying discharge summaries.

With the parsed forms as input, and using mapping information 103, the phrase regularizer 13 composes regular terms as described above.

From the regularized phrases, the filter module 14 deletes information on the basis of parameter settings. For example, a parameter can be set to call for removal of negative findings.

The encoder module 15 uses a table of codes 104 to translate the regularized forms into unique concepts which are compatible with a clinical controlled vocabulary.

Fig. 2 shows an interface module 21, and the MedLee system 22 of Fig. 1. The interface module 21 may be domain-specific, and it may serve, e.g., to separate formatted sections from non-formatted sections in a report. Also, the interface 22 may serve to pass chosen parameter values to the MedLEE system 22 and to pass output from the MedLEE system. For example, such an interface can be designed for communication over the World-Wide Web or a local network, for input to or output from MedLEE.

Conveniently, each module is software-implemented and stored in random-access memory of a suitable computer, e.g., a work-station computer. The software can be in the form of executable object code, obtained, e.g., by compiling from source code. Source code interpretation is not precluded. Source code can be in the form of sequence-controlled instructions as in Fortran, Pascal or "C", for example. Alternatively, a rule-based system can be used such a Prolog, where suitable sequencing is chosen by the system at run-time.

An illustrative portion of the MedLEE system is shown in the Appendix in the form of a Prolog source listing with comments. The following is further to the comments.

Process_sents with get_inputsents, process_sects and outputresults reads in an input stream, processes sections of the input stream according to parameter settings, and produces output according to the settings. Among parameters supplied to Process_sents are the following: Exam (specifying the domain), Mode (specifying the parsing mode), Amount (specifying the type of filtering), Type (specifying the output format) and Protocol (html or plain). Process_sents is called by another predicate, after user-specified parameters have been processed.

Process_sects with get_section and parse_sentences gets each section and generates intermediate output for the sentences in each section.

Outputresults with removefromtarg, write, writelines, markupsents and outputhl7 filters output if appropriate, produces output in the appropriate format and optionally including formats tags for selected words of the original sentence, and produces error messages and an end-of-output message.

Setargs sets arguments or parameter values based on user input or by default.

Removefromtarg filters formatted output by leaving only positive clinical information and by removing negative findings from the formatted output. Another parameter, parc, removes findings associated with past information from the formatted output. Any number of different filters can be included as suitable.

Writelines produces one line per finding, in list format. Writeindentform and writeindentform2 produce output in indented form.

Markupsents envelopes the original sentence with tags so that the clinical information is highlighted. Different types of information can be highlighted in different colors by use of an appropriate browser program such as Netscape, for example.

Outputhl7 converts output to appropriate form for database (xformtodb) and writes out the form in hl7 in coded format. This process uses synonym knowledge and an encoding knowledge base.

APPENDIX

```
% fail an unknown predicate
:-unknown(_,fail).
:- op(900,  fy,  [\+,not,once]). %  same priority and type as \+
:- op(700, xfx,  [\=,--=]).      %  same priority and type as = or ==
:- dynamic(domain/1).            %  domain being processed
:- dynamic(outputform/1).        % form of output (needed to distinguish
                                 % markup of text from formatting forms
:- dynamic(currentsect/1).       % section for outputting results
% Use when testing grammar - use default parameters for section,type,mode
testing(Exam,Form,Amount,Infile,Outfile) :-
    see(Infile), seen, see(Infile),
    get_inputsents([],Toklist),
    retractall(domain(_)),
    assert(domain(Exam)),
    retractall(paragno(_)),
    assert(paragno(1)),
    retractall(sentno(_)),
    assert(sentno(0)),
    retractall(outputform(_)),
    assert(outputform(Form)),
    retractall(currentsect(_)),
    process_testing(Toklist,Exam,Amount,Outfile).
process_testing([],_,_):- !.
process_testing(Toklist,Exam,Amount,Outfile) :-
    get_sentence(Toklist,Sent,Rest),
    parse_sentences(Sent,Pmtlist,Outfail,Outundefs,OutunSents,
            testing,bp,Exam,_,_,0),
    tell(Outfile),
    write_sentences(Sent),
    outputform(Type),
    outputresults(Pmtlist,Outfail,Outfile,Outundefs,Outfile,OutunSents,
            Outfile,Amount,Type,Exam,1,0,_,exe,plain),
    process_testing(Rest,Exam,Amount,Outfile).
```

```
process_sents(Exam,Sect,Mode,_,Outfile,Amount,Type,Compno,DocComp,Errfile,
        Unfile,Caller,Protocol) :-
    get_inputsents([],Toklist), !, % read in and tokenize input
    tell(Outfile),
    ( % write out output label if writing using client/server model
      % or if protocol is html
      (Caller = server, ; Protocol = html, !), % beginning of output
      write('<html> <head> <title>'),
      write('Output Generated by MedLEE'),
      write('</title> </head>'), nl,
      write('<body> <H1> Output Generated by MedLEE </H1> <HR> '), nl,
      new_line(html), nl
      ; true
    ),
    (Toklist = [], !,
     write_message(Errfile,'Input Error: No input entered',Caller,
          '<HR><H3> Application Message: No input entered </H3><HR>')
     ; % check for legitimate section header if Sect = 'mixed'
     Sect = mixed, get_section(Toklist,_,_,S,_), S = [], %no header found
      write_message(Errfile,'Input Error: No legitimate section header',
            Caller,
            '<HR><H3> Application Message: Legitimate section header is missing </H
3><HR>')
      ;
      retractall(domain(_)),
      assert(domain(Exam)),   % used in grammar to permit certain rules
      retractall(outputform(_)),
      assert(outputform(Type)), % used in parser and formatter
      retractall(currentsect(_)),  % used in formatting output
      assert(currentsect(Sect)),
```

```
markup(Toklist,Toklist2,Sect), % markup up in certain conditions
process_sects(Toklist2,Sect,Mode,Exam,Fmtlist,Failed,Undef,
        UnSent,1),
outputresults(Fmtlist,Failed,Errfile,Undef,Unfile,UnSent,Outfile,
                Amount,Type,Exam,Compno,DocComp,_,Caller,Protocol)
).
% case where there is no more input.
process_sects([],_,_,_,[],[],[],[],_) :- !.
% sections are specified in input - there are several sections in input
process_sects(Toklist,mixed,Mode,Exam,Fmtlists,Fails,Undefs,
        UnSents,_) :-
    get_section(Toklist,Sents,Rest,Sect,Printname),!,  %get section of report
    parse_sentences(Sents,Fmtlist,Failed,Undef,UnSent,
                Sect,Mode,Exam,_,_,1), !,
    process_sects(Rest,mixed,Mode,Exam,Fmtlist2,Fail2,Undef2,
                UnSent2,_),
    (outputform(htext), !, Fmt0 = [[section,[Printname]]]; % name of section
     Fmt0 = []
    ),
    append([Fmt0,Fmtlist,Fmtlist2],Fmtlists),  % list of formatted output
    append(Failed,Fail2,Fails),  % list of sentences having parsing errors
    append(Undef,Undef2,Undefs), % list of words not in lexicon
    append(UnSent,UnSent2,UnSents).  % list of sentences with undefined words.

% input is a single section
process_sects(Toklist,Sect,Mode,Exam,Fmtlist,Failed,Undef,
        UnSent,_) :-
    Sect \= mixed,
    retractall(paragno(_)),
    assert(paragno(1)),
    retractall(sentno(_)),
    assert(sentno(0)),
    parse_sentences(Toklist,Fmtlist1,Failed,Undef,UnSent,
                Sect,Mode,Exam,_,_,1), !,
    (outputform(htext), Fmtlist1 \= [], !,
     append([[[section,[Sect]]]],Fmtlist1,Fmtlist);
     outputform(htext), Fmtlist = [], !, Fmtlist = [[[section,[Sect]]]];
     Fmtlist = Fmtlist1
    ).
```

```
outputresults(Fmtlist0,Failed,Errfile,Undef,Unfile,UnSent,Outfile,
              Amount,Type,Exam,Compno,DocComp,NewCompno,Caller,Protocol) :-
    (Amount = full, Fmtlist = Fmtlist0, !;    % do nothing to formatted output
     Amount = short, removemodifiers(Fmtlist0,Fmtlist),!;
     %Amount = short, removemodifiers(Fmtlist0,Fmtlist1),!;
      % remove neg and/or old findngs
      member(Amount,[pac,pos]), removefromtarg(Amount,Fmtlist0,Fmtlist1),!,
      fixuplists(Fmtlist1,Fmtlist,Type)   %produces extra brackets
    ),
    (Protocol = html, !, Op = html;
     Caller = server, !, Op = html;
      Op = plain),
    (Type = nested, !,   write(Fmtlist), new_line(Op);
     Type = line,  !, writelines(Fmtlist,Op), new_line(Op), !;
     Type = htext, !, markupsents(Fmtlist), new_line(Op), !;
     Type = indented, !, nl, writeindentform(Fmtlist,Type,Op), !;
     Type = hl7l, !, write('<hl7>'),
     outputhl7(Fmtlist,Exam,Outfile,Compno,DocComp,NewCompno,Op),
      write('</hl7>'),    % end of hl7 part of output
       write('<line>'),
        (Fmtlist \= [], writelines(Fmtlist,Op),!
          ; true
        ), % write non-empty
        write('</line>'), nl, !; %nested part
     outputhl7(Fmtlist,Exam,Outfile,Compno,DocComp,NewCompno,Op)  %default
```

```
  ),
  (Caller = server,
   write_message(Unfile,Undef,Caller,'<HR><H2> Undefined Words </H2>')
   ,
   Caller = exe, Undef \= [],
   write_message(Unfile,Undef,Caller,'***** Undefined Words *****')
   %write_highlight([],UnSent,Caller)
   ,
    true
   ),
  %( Caller = server, UnSent \= [], Undef \= [], !,
   %  write('<P> Undefined Words are Highlighted in Sentences Not Parsed.')
   % , true),
  % (
    % Undef = [], !, %no undefined words
    % Unfile = [], !,
    % tell(Unfile),
    % write('**** Undefined Words in domain '),
    % write(Exam), write(' ****'), nl,
    % write(Undef), nl
      % write_sentences(UnSent)
  % ),
  (Caller = server,
   write('<HR><H2>Sentences/Phrases Not Parsed </H2>'),!,
   write_highlight(Undef,UnSent,Caller),
   write_highlight([],Failed,Caller)
   ,
   Caller = exe, Errfile \= [], Failed \= [],
   tell(Errfile),
   write('***** Sentences/Phrases Not Parsed *****'), nl,
   %write_highlight(Undef,UnSent,Caller),
   write_highlight([],Failed,Caller)
   ,
   true    % no Errfile to write to
  ),
```

```
    (Op = html, !, write('</body></html>');  % end document
      true).
    %  (Failed = [], !;    %no parsing failures
    %     Errfile = [], !;    % don't write problem messages
    %     tell(Errfile),
    %     % write('**** Grammar Failures in domain '),
    %     % write(Exam), write(' ****'), nl,
    %     write_sentences(Failed), nl
    %  ).

% set_args: Process options
% Argument options
% -a Amount of output desired. The choices are:
%          full (no filtering of output is done)
%          pos  (only positive findings are shown)
%          pac  (only current and positive findings are shown).
%          short (certain modifiers are not shown)
% -c Component Number (starting component number for HL7 output
%                      default is 1)
% -d Component where document number is stored (default is 0)
% -e Examtype (otherwise default is chestxray)
% -p ProbFile (otherwise default is problem messages are not written to file)
% -i Infile (if input is supplied by file and not standard input
% -s Section  (default is impression)
% -m Mode (default is bp; the 6 choices are bp, model - mode5)
% -o Outfile (if output should be file and not standard output)
% -? Provide list of default arguments
% -f or -t Type of output (default is hl7; the choices are:
%          hl7, nested, line, hl7t, htext
```

```
%       The line version has nesting but consists of single
%          unconnected findings;
%       The h171 version has both h17 + line; each is tagged
% -pr Protocol - html or plain
% -u Undefs (otherwise default is - undefined messages are not written
%     to a file)
set_args(Args,Examtype,Section,Mode,Infile,Outfile,
         Amount,Type,Component,Startdoc,Prbfile,Undef,Protocol) :-
        set_examtype(Args,Examtype),
        set_section(Args,Section,Examtype),
        set_mode(Args,Mode), set_amount(Args,Amount),
        set_protocol(Args,Protocol),
        set_infile(Args,Infile), set_outfile(Args,Outfile), set_type(Args,Type),
        set_comp(Args,Component), set_startcomp(Args,Startdoc),
        set_prbfile(Args,Prbfile), set_undefs(Args,Undef).

set_examtype(Args,Examtype) :-
      % -e or e option specifies exam type
        (nextto('-e',E,Args); nextto('e',E,Args)), !,
        examis(E,Examtype).

examis(chestxray,chestxray) :- !.
examis(E,chestxray) :-
      % MEDCODES for descendants of chestxrays
        member(E,['10220','10221','27489','27618','27619','27620',
                  10220,  10221,  27489,  27618,  27619,  27620,
                 '27621','27622','27624','27625','27626','27627',
                  27621,  27622,  27624,  27625,  27626,  27627,
                 '27628','27629',
                  27628,  27629,
                 '27630','27631','27632',
                  27630,  27631,  27632,
                 '40607','40676','40680','40682','40684','40689',
                  40607,  40676,  40680,  40682,  40684,  40689,
                 '40692','40744','40759','40762','40764','40829',
                  40692,  40744,  40759,  40762,  40764,  40829,
```

```
        '40862','40863','40877','40880',
         40862,  40863,  40877,  40880,
        '40910','40923','40924','40933','40934','40951','40952',
         40910,  40923,  40924,  40933,  40934,  40951,
         40952,
        '40966','40969','40974','41012','41016','41017','41852',
         40966,  40969,  40974,  41012,  41016, 41017,
         41852,
        '41854', 41854]), !.
examis(mammography,mammography) :- !.
examis(mammogram,mammography) :- !.
examis(mammograms,mammography) :- !.
examis(E,mammography) :-
        % MEDCODES for descendants of mammograms
        member(E,['40728','40778','40864','40966','42264','27623','27625',
                  40728, 40778, 40864, 40966, 42264, 27623, 27625,
                  '40863','33920', 40863, 33920]), !.

examis(dsum,dsum) :- !.
examis(oprpt,oprpt) :- !.
examis(echo,echo) :- !.
examis(_,[]).

set_comp(Args,Component) :-
        % -c or c option
        (nextto('-c',C,Args); nextto(c,C,Args)),
        name(C,Lchars), number_chars(Component,Lchars). %convert to number
set_comp(_,1).      %default component number for h17
```

```
set_startcomp(Args,Startdoc) :-
    (nextto('-d',D,Args); nextto(d,D,Args)),
    name(D,Dchars), number_chars(Startdoc,Dchars).
set_startcomp(_,0).   % default parent finding

set_section(Args,Section,Examtype) :-
        (nextto('-s',S,Args); nextto(s,S,Args)),!,   % -s or s option
            sectionis(S,Section,Examtype).
set_section(_,'report impression item',chestxray).   % default section
set_section(_,'report impression item',mammography).   % default section
set_section(_,'report clinical information item',dsum).   % default section
sectionis('34900','report description item',_) :- !.
sectionis(34900, 'report description item',_) :- !.
sectionis(description,'report description item',_) :- !.
sectionis('34901','report impression item',_) :- !.
sectionis(34901,'report impression item',_) :- !.
sectionis(impression,'report impression item',_) :- !.
sectionis('34902','report clinical information item',_) :- !.
sectionis(34902,'report clinical information item',_) :- !.
sectionis('clinical information','report clinical information item',_) :- !.
sectionis(clininfo,'report clinical information item',_) :- !.
sectionis(clinical,'report clinical information item',_) :- !.
sectionis(mixed,mixed,_) :- !.   % section headers are included in text
sectionis(testing,testing,_) :- !.
sectionis(_,'report impression item',mammography) :- !.   % default section
sectionis(_,'report impression item',chestxray) :- !.
sectionis('discharge diagnoses','report discharge diagnosis item',_) :-!.
sectionis('history of present illness','report history of present illness item',_) :
- !.
sectionis('chief complaint','report chief complaint item',_) :- !.
sectionis('past medical history','report past medical history item',_):- !.
sectionis('review of systems','report review of systems item',_) :- !.
sectionis('hospital course','report hospital course item',_) :- !.
sectionis('physical examination','report physical examination item',_) :- !.
sectionis('social history','report social history item',_) :- !.
sectionis(X,X,dsum) :- !.
```

```
set_mode(Args,Mode) :-
    (nextto('-m',M,Args); nextto(m,M,Args)), !,
        models(M,Mode), !.
set_mode(_,bp).    % default output type

models(relax,mode2) :- !.
models(strict,mode1) :- !.
models(skip,mode4) :- !.
models(longest,mode3) :- !.
models(best,bp) :- !.
models(mode1,mode1) :- !.
models(mode2,mode2) :- !.
models(mode3,mode3) :- !.
models(mode4,mode4) :- !.
models(mode5,mode5) :- !.

set_type(Args,Type) :-
    (nextto('-t',Type,Args); nextto('t',Type,Args);
        nextto('-f',Type,Args); nextto('f',Type,Args)
    ), !,    % -f ,f, -t, or t option
        member(Type,[nested,line,indented,hl7,hl71,drg,daumary,htext]), !.
set_type(_,hl7).    % default form
set_amount(Args,Amount) :-
    (nextto('-a',Amount,Args); nextto('a',Amount,Args)), !,  % -a or a option
        member(Amount,[full,short,pac,pos]), !.
set_amount(_,full).    % default type
set_protocol(Args,Protocol) :-
```

```
    (nextto('-pr',Protocol,Args); nextto('pr',Protocol,Args)),
        member(Protocol,[html,plain]), !.
set_protocol(_,plain).
set_undefs(Args,Undefs) :-
    nextto('-u',Undefs,Args); nextto(u,Undefs,Args) , !. % undef file option
set_undefs(_,[]).    % default is no file of undefineds created

set_infile(Args,Infile) :-
    nonvar(Infile), !,  % Infile is set already
    nextto('-i',Infile,Args), !;
    nextto(i,Infile,Args), !.
set_infile(_,user_input).    % default is standard input

set_prbfile(Args,Prbfile) :-
    nextto('-p',Prbfile,Args), !; nextto(p,Prbfile,Args), !. % prob file option
set_prbfile(_,[]).    % default is no file of problems is created

set_outfile(Args,Outfile) :-
    nonvar(Outfile), !,     % Outfile is already set
    nextto('-o',Outfile,Args), !; nextto(o,Outfile,Args), !. % outfile option
set_outfile(_,user_output).    % default is standard output

new_line(html) :- write('<br>'), !.
new_line(server) :- write('<br>'), !.
new_line(exe) :- nl.
new_line(plain) :- nl.
write_message(_,[],exe,_) :- !.
write_message([],_,exe,_) :- !.
write_message(_,[],plain,_) :- !.
write_message([],_,plain,_) :- !.
write_message(File,Contents,Caller,Message) :-
    ( member(Caller,[exe,plain]), tell(File), !
    ;
    true),
    write(Message), new_line(Caller),
    (Contents = []; write(Contents), new_line(Caller)).
```

```
write_highlight(_,[],_) :- !.
write_highlight(Undef,[Word|UnSent],Caller) :-
    member(Caller,[html,server]), !,
      (member(Word,Undef), write('<strong>'), write(Word), write('</strong>')
      ; write(Word)),
      ( sentend([Word],Caller), write_highlight(Undef,UnSent,Caller),!;
        write(' '), write_highlight(Undef,UnSent,Caller)).
write_highlight(Undef,[Word|UnSent],Caller) :-
    member(Caller,[exe,plain]),
      is_list(Word), !,  % bracketed phrase
       write_highlight(Undef,Word,Caller),  % write out words in phrase
       write(' '), write_highlight(Undef,UnSent,Caller).
write_highlight(Undef,[Word|UnSent],Caller) :-
    member(Caller,[exe,plain]), !,
      write(Word),  % write individual word
      ( sentend([Word],Caller), write_highlight(Undef,UnSent,Caller), !;
        write(' '), write_highlight(Undef,UnSent,Caller)).
write_highlight(_,_,plain) :- !.
write_highlight(_,_,exe) :- !.
sentend([X|_],Caller) :-
    member(X,['.','!','?']), new_line(Caller), !.
removemodifiers([],[]) :- !.
removemodifiers([[sentence,['']]],[]) :- !. % at end of file marker
removemodifiers([[section,S]|Fmts],[[section,S]|NewFmts]) :-
    removemodifiers(Fmts,NewFmts), !.
removemodifiers([S1|Rest],[NewS1|NewRest]) :-
    removemods(S1,NewS1),
```

```
    removemodifiers(Rest,NewRest), !.
% removemods(+Pmts,-NewPmts): removemods removes certain modifiers from
%       Pmts when mode is "short" form, resulting in NewPmts
removemods([],[]):- !.
removemods([[sentence,S]|Pmts],[[sentence,S]|NewPmts]) :-
    removemods(Pmts,NewPmts), !.
removemods([Pmt1|Rest],[NewPmt1|NewRest]) :-
    chkandremove(Pmt1,NewPmt1),
    removemods(Rest,NewRest), !.
%removemods([[finding,demo|L]|Rest],[[finding,demo|L]|NewRest]) :-
%    removemods(Rest,NewRest), !.
%removemods([Pmt1|Rest],[NewPmt1|NewRest]) :-
%    chkandremove([Pmt1|Rest],
%      %removefromlist(Pmt1,NewPmt1),
%    removemods(Rest,NewRest), !.  % remaining ones
removefromlist([],[]) :- !.
removefromlist([Pmt1|Rest],[NewPmt1|NewRest]) :-
    chkandremove(Pmt1,NewPmt1),    % formats
    removefromlist(Rest,NewRest), !.
chkandremove([Type|Rest],[Type|Rest]) :-    % leave alone
    member(Type,[sentence,section]), !.
%chkandremove([finding,demo|Rest],[finding,demo|Rest]) :- !.   % leave alone
chkandremove([Type|_],[]) :-    % remove certain type of formats first
    skiptypes(Type), !.
chkandremove([Type,Value],[Type,Value]) :- !.   % no mods to remove
chkandremove(Pmt,NewPmt) :-
    removemod(Pmt,NewPmt).
% removemod(+OnePmt,-NewPmt):
removemod([Type,Value|Mods],[Type,Value|NewMods]) :-
    processmods(Type,Mods,NewMods), !.
removemod([],[]).
% check each modifier - leave more modifiers for finding
processmods(_,[],[]).
processmods(Type,[Mod1|Rest],NewMods) :-
    Type \= finding,
    chkmod1(Mod1,NewMod),
```

```
processmods(Type,Rest,NewMods1),
  ( NewMod \= [], append([NewMod],NewMods1,NewMods);
    NewMod = [], NewMods = NewMods1), !.
processmods([finding,[Mod1|Rest],NewMods]) :-
  chkmod2(Mod1,NewMod),
  processmods(Type,Rest,NewMods1),
  ( NewMod \= [], append([NewMod],NewMods1,NewMods);
    NewMod = [], NewMods = NewMods1), !.

chkmod1([Type|Rest],NewMod) :-
  okmods1(Type), NewMod = [Type|Rest], !;
  NewMod = [], !.
chkmod1([],[]).
chkmod2([Type|Rest],NewMod) :-    % leave more mods for findings
  okmods2(Type), NewMod = [Type|Rest], !;
  NewMod = [], !.
chkmod2([],[]).
skiptypes(Type) :-
  member(Type,[status,prev_info,realtime,normalfinding,demo]).
okmods1(Type) :-
  member(Type,[status,certainty,bodyloc,descriptor,region,sentid,
              'section of examination']).

okmods2(Type) :-
  member(Type,[status,certainty,bodyloc,descriptor,region,sentid,
              degree,change,
              'section of examination',age,ethnic,sex,race]).

removefromtarg(_,[],[]) :-!.
removefromtarg(_,[[sentence,[''']],[]) :- !.
```

```
removefromtarg(Amount,[S1|Rest],Rem) :-
    removefromsent(Amount,S1,NewS1),
    removefromtarg(Amount,Rest,NewRest),
    removefromtarg(Amount,Rest,NewRest),
    (NewS1 \= [], Rem = [NewS1|NewRest], !;
        Rem = NewRest, !).
removefromsent(_,[section,S],[section,S]) :-
    retractall(currentsect(_)),
    assert(currentsect(S)).
removefromsent(_,[[section,S]],[[section,S]]) :-
    retractall(currentsect(_)),
    assert(currentsect(S)).
removefromsent(Amount,[[sentence,S]|Pmts],[[sentence,S]|NewPmts]) :-
    removefindngs(Amount,Pmts,NewPmts), !.
removefromsent(_,[],[]) :- !.
removefromsent(Amount,Pmts,NewPmts) :-      %add extra bracket when there is
    removefindngs(Amount,[Pmts],NewPmts), !.  % no sentence prefix
removefindngs(_,[],[]) :- !.
removefindngs(Amount,[F1|Rest],Rem) :-
    removefindng(Amount,F1,NewF1),
    removefindngs(Amount,Rest,NewRest),
    (NewF1 \= [], Rem = [NewF1|NewRest], !;
        Rem = NewRest), !.
removefindng(Amount,[F1|Rest],[F1|Rest]) :-
    chktypeandpacs(Amount,[F1|Rest]), !.  % these formats are positive, curr, not
                                          % normal
removefindng(_,F,[]).          % this format is normal, negative, or old
%chktypeandpacs([Type|_]) :-
%    member(Type,[sentence,section]), !.   % leave these alone
chktypeandpacs(Amount,[Type,_|Mods]) :-
    chktargtype(Type,Mods),     %
    chkpacs(Amount,Mods).
chktargtype(finding,Mods) :-
    \+ chkfornormal(Mods), !.     % change mod = better, descr mod = normal
chktargtype(Type,_) :-
    \+ member(Type,[normalfinding,status,date,timeper,prev_info]).
```

```
chkpacs(_,[]) :- !.
chkpacs(Amount,Mods) :-
    chkforpos(Mods),     % remove neg. only; don't filter time
      ( Amount = pos, !;
        chkforsect(Mods),
        chkforcurdate(Mods)).
chkfornormal(Mods) :-
   (setof(X,member([change,X],Mods),Changes),
     (outputform(htext), gettargets(Changes,Newchanges), !;  % target form
       Newchanges = Changes),
     member([better],[Newchanges]), !;
    setof(X,member([descriptor,X],Mods),Descrs),
     (outputform(htext), gettargets(Descrs,Newdescrs), !;
       Newdescrs = Descrs),
     member(normal,Newdescrs), !).
chkforpos(Fmt) :-
   (setof(X,member([certainty,X],Fmt),Certs),!,    % certainty modifiers
     (outputform(htext), gettargets(Certs,Newcerts), !;
       Newcerts = Certs),
     \+ isneg(Newcerts), !;
     true).
chkforcurstat(Mods) :-
   (setof(X,member([status,X],Mods),Stats), !,      % status modifiers
     (outputform(htext), gettargets(Stats,Newstats), !;
       Newstats = Stats),
     \+ isold(Newstats), !;
     true).
chkforsect(Mods) :-
   \+ outputform(htext),   !,  % leave out if past history section
```

```
    \+ ispasthistory(Mods), !,
      chkforcurstat(Mods).   % not past history - check status for current
  chkforsect(Mods) :-    % htext mode, check status for current
      outputform(htext),
      ( ispasthistory(Mods), !,     % leave alone if in past history section
        chkforcurstat(Mods)
      ).
  ispasthistory(Mods) :-
      member(['section of examination',X],Mods),
      X = 'past history report item', !.
  ispasthistory(Mods) :-
      currentsect(S),
      member(S,['past history report item',['PAST MEDICAL HISTORY:.']]).

  chkforcurdate(Mods) :-
    \+ chkfordate(Mods),
    \+ chkforpastadm(Mods).
  chkfordate(Mods) :-
      member([date|_],Mods).    % dates are generally in the past
  chkforpastadm(_) :- fail.
  gettargets([],[]) :- !.
  gettargets([W1|Rest],[T1|Trest]) :-
      foundword(W1,_,T1),     % target for W1
      gettargets(Rest,Trest), !.

  isneg(X) :-
      intersect(X,[no,negative,deny,'rule out']).
  isold(X) :-
      intersect(X,['risk factor',resolved,end,previous,'exposed to',
          'positive family history',future,removed,need,prepare,post,
          'negative family history',hold,'past history',postoperative,
          prepare,'ran out','treatment option','strong family history',
          tendency,weaned,withdrawal,avoid,inactive,need,offer,plan,soon]).
  % convert output to database form and write out hl7 with codes
```

```
outputh17(Fmtlist,Exam,Outfile,Compno,DocComp,NewCompno,Caller) :-
        xformtodb(Fmtlist,Newfmtlist,Exam), !,  % database form
        writeh17(Newfmtlist,Outfile,Compno,DocComp,NewCompno,Caller). % h17
    fixuplists([],[],_) :- !.
    fixuplists(P,F,htext) :- !.  % output is correct for markup
    fixuplists([F1|Rest],Fixed,Type) :-   % remove extra bracket around sentences
        fixuplists(Rest,NewRest,Type),
        append(F1,NewRest,Fixed), !.
    % write out one finding in nested form per line
    writelines([],_) :- !.     % no more findings
    writelines([Onefinding|Morefindings],Caller) :-
        write(Onefinding), new_line(Caller),
        writelines(Morefindings,Caller), !.
    writeindentform2([],_,_) :- !.
    writeindentform2(Findings,Type,html) :-
        write('<pre>'), nl,
        writeindentfndgs(Findings,Type,plain),
        write('</pre>'), nl.
    writeindentform2(Findings,Type,plain) :-
        writeindentfndgs(Findings,Type,plain), !.
    writeindentfndgs([],_,_) :- !.
    writeindentfndgs([F1|Rest],Type,Op) :-
        writeindented(F1,Type,Op),
        writeindentfndgs(Rest,Type,Op), !.
    writeindentform(Finding,Type,html) :-
    write('<pre>'), nl,
    writeindented(Finding,Type,plain),     % in pre mode - new line is recognized
    write('</pre>'), nl.                   %                in html
    writeindentform(Finding,Type,plain) :-
        writeindented(Finding,Type,plain).
```

```
writeindented([],_,_) :- !.   % no more findings
writeindented([Onefinding|Morefindings],Type,Caller) :-
   writeind(Onefinding,Type,Caller), writeindented(Morefindings,Type,Caller), !.
writeind([],_,_) :-!.
writeind([failure],_,Caller) :- write('--parsing failure--'),
     %nl, !.
     new_line(Caller), !.
writeind([Type,Finding|Mods],Output,Caller) :-
     (Output = indented; Output = dsummary), !,
      write(Type), write(':'), write(Finding),
           nl,
           %new_line(Caller),
           writemods(Mods,11,Caller),
           nl.
           %new_line(Caller).
% while testing DRGs write out findings relevant to DRGs only
writeind([finding,Finding|Mods],drg,Caller) :-
      drgchk(Finding),    % is Finding relevant for DRG
      checkmods(Mods), !, % check that Mod is not certainty = 'no'
      writeind([finding,Finding|Mods],indented,Caller).
writeind(_,drg,_) :- !.  % no output for this finding
writemods([],_,_) :- !.    % no more mods
writemods([Onemod|Moremods],Tabno,Caller) :-
    writeonemod(Onemod,Tabno,Caller), writemods(Moremods,Tabno,Caller), !.
writeonemod([],_,_) :- !.
writeonemod([Mod,Value|Rest],Tabno,Caller) :-
    writeblanks(Tabno), write(Mod), write('>> '), write(Value),
      nl, !,
      %new_line(Caller), !,
      (Rest = []; Newtab is Tabno + 8, writemods(Rest,Newtab,Caller) ).
writeonemod(L,Tabno,Caller) :-
   strip(L,New1), !, writeonemod(New1,Tabno,Caller).
writeonemod(_,_,_).
writeblanks(0) :-!.
writeblanks(Tabno) :-
```

```
    write(' '), T is Tabno - 1,
        writeblanks(T), !.
drgchk(Finding) :-
    drgs(L),    %list of findings for drg
    member(Finding,L).
checkmods(M):-
  \+ member([certainty,no],M).
writeoutsent([]) :- !.
writeoutsent([Word|Rest]) :-
  number(Word), write(Word), !,
    (Rest \= [], write(','), !, writeoutsent(Rest);
     true), !.
markupsents([]) :-!.
markupsents([[sentence,['.']]]) :- !.   % at end of file marker
markupsents([[section,S]|Pmts]) :-
    write('<p>'),
    write_sentences(S), !,
    retractall(currentsect(_)),
    assert(currentsect(S)),
    markupsents(Pmts).
markupsents([[[section,S]]|Pmts]) :-
    write_sentences(S), !,
    markupsents(Pmts).
markupsents([S1|Rest]) :-
    markupsentlist(S1),
    markupsents(Rest), !.
markupsentlist([[sentence,S]|Pmts]) :-
    markupformats(S,Pmts,MarkedSent), !,
      write_markedsent(MarkedSent), !.   %write out marked up sentence
```

```
write_markedsent([W1,W2,W3|S]) :-
    W1 = '<b><font color = ',
    write(W1), write(W2), write(' '), write(W3), write(' '),
    write_sentences(S).
write_markedsent(S) :- write_sentences(S).

markupformats(S,[],S) :- !.     % no markup is needed
markupformats(S,[Fmt1|Rest],MSent) :-
    color_markup(S,Fmt1,MS1),    % markup 1st part
    markupformats(MS1,Rest,MSent), !.   % markup rest
%color_markup(+L,+Fmt,-MFmt):
color_markup(L,[],L).
color_markup(L,[finding,Value|Mods],NewL) :-
    Type = finding, Value \= demo,
    Color = '"brown"',
    (setof(X,member([change,X],Mods),Changes),
        markup_list(L,Changes,Color,NewL1), !;
    setof(X,member([degree,X],Mods),Degrees),
        markup_list(L,Degrees,Color,NewL1), !;
    L = NewL1),
    (setof(X,member([descriptor,X],Mods),Descrs),
        markup_list(NewL1,Descrs,Color,NewL2);
    NewL2 = NewL1),
    write_color(NewL2,Value,Color,NewL).
color_markup(L,[Type,Value|Mods],NewL) :-
    (Type = problem, Color = '"brown"', NL = L;
    Type = med, medcolor(L,Mods,NL,Color), !;
    Type = procedure, Color = '"blue"', NL = L;
    Type = device, Color = '"blue"', NL = L), !,
    (Type = procedure, gettargets([Value],Proc),
        member(Proc,[view,examination]), !;
    write_color(NL,Value,Color,NewL)).
%color_markup(L,[finding,demo|Mods],NewL) :-
```

```
%change or degree mod
% for findings

    % descriptor

% finding

% differentiate meds from
% reaction to meds

    % dont markup generic procedure

%get age,sex,race,ethnic
```

```
color_markup(L,_,L).
medcolor(L,Mods,NL,'"brown"') :-
    currentseot(S), member(S,['report allergy item',['ALLERGIES:']]), !,
      (Mods = [], L = NL, !;
       chkforreact(L,Mods,NL)).
medcolor(L,[],L,'"green"') :- !.  %not allergy section - medication
medcolor(L,Mods,NL,'"brown"') :-
    chkforreact(L,Mods,NL).

chkforreact(L,Mods,NL) :-      % markup up reaction to med also
    setof(X,member([reaction,X],Mods),React),
    gettargets(React,Tarreact),
    (llathasreact(Tarreact), markreact(React,Tarreact,L,NL);
      L = NL).
medcolor(L,_,L,'"green"').    % default
markreact([],[],L,L) :- !.
markreact([R|Rest],[Tar|TarRest],L,NL) :-
    (lsreact(Tar), write_color(L,R,'"brown"',NewL),
       markreact(Rest,TarRest,NewL,NL), !;
       markreact(Rest,TarRest,L,NL), !).
markreact(_,_,L,L).
lsreact(Tar) :-      % adverse reaction
    member(Tar,[allergy,intolerant,'not effective','toxic','side effect',
                'not better',reaction]).

llathasreact(Tarreact) :-
    intersect(Tarreact,[allergy,intolerant,'not effective','toxic','side effect',
                'not better',reaction]).
% markup_list(+Sentlist,+Wordlist,+Color,-NewL)
markup_list(L,[],_,L) :- !. % no more elements to markup
markup_list(L,[Value|Rest],Color,NewL) :-
```

```
write_color(L,Value,Color,New),
markup_list(New,Rest,Color,NewL).
write_color(L,Value,Color,NewL) :-
    atomic(Value), !, suffix(L,[Value|Rest]), %  word in sentence list
    append(Prefix,[Value|Rest],L),   % part of sentence before word
    (notmarked(Prefix), !,   % check word is not marked already
    surround(Value,Color,MVal), append([Prefix,MVal,Rest],NewL);
    write_color(Rest,Value,Color,NewR),!,   % mark up latter part of sentence
    append(Prefix,[Value|NewR],NewL);   % add to first part
    L = NewL    % don't do anything
    ).
write_color(L,Value,Color,NewL) :-
    Value = [W1|_], suffix(L,[W1|Rest]), % word1 of phrase in sentence
      append(Prefix,[W1|Rest],L),   % prefix is part of L before phrase
      (notmarked(Prefix),   % phrase is not marked already
      last(Wn,Value), suffix(Rest,[Wn|Restn]),   % last word in phrase
      add_colorprefx(W1,Color,MW1), % markup before W1 of phrase
      append(Phrase,[Wn|Restn],Rest),   % get rest of phrase in sentence
      add_colorsufx([Wn],MWn), % markup up end of phrase
      append([Prefix,MW1,Phrase,MWn,Restn],NewL), !, % put all pieces together
      write_color(Rest,Value,Color,NewR), % write up latter part of sentence
      append(Prefix,[W1|NewR],NewL), !).   % leave sentence unmarked
write_color(L,_,_,L).
surround(W,Color,CList) :-
    add_colorprefx(W,Color,PreL),
    add_colorsufx(PreL,CList).
% add_colorprefx(+W,+Color,-CW): W is word, CW is a list containing
%   starting markup for color (i.e. markup preceeds W)
add_colorprefx(W,Color,['<b><font color = '|CList]) :-
    append([[Color],[' size=+1>'],[W]],CList).
% add_colorprefx(+L,-W): L is a list, W is a list containing ending
%   markup for a color which is in a list preceded L in sentence
add_colorsufx(L,SL) :-
    append(L,['</font></b>'],SL).
```

```
notmarked([]) :- !.
notmarked(Prefix) :-
    last(X,Prefix),
    X \= ' size=+1>',
writeoutsent([Word|Rest]) :-
  write(''''), write(Word), write(''''), !,
  (Word = '.', write('.'), !; true),
  (Rest \= [], write(','), !, writeoutsent(Rest), !;
    true), !.

\032
:- op(700, xfx, ['\=']).
xform(Infile,Dbform,Examtype) :-
    see(Infile), seen, see(Infile),
    get_output(List),
    (List = end_of_file, !;
      xformtodb(List,Dbform,Examtype)).

get_output(List) :-
    read(List).

xformtodb([],[],_) :- !.
xformtodb([X|Rest],Dbform,Examtype) :-
  % one finding or recommendation
  ( isonefinding(X), !, (todbform(X,Newx,Examtype), Newform = [Newx]
                          /
                          Newform = []), !
  /
  % multiple findings or recommendations
    ismultifinding(X), !, (tdbformulti(X,Newform,Examtype)
```

```
                    !
                    Newform = [])
    ; % is not a finding - don't produce output
      Newform = []
    ),
    xformtodb(Rest,Newrest,Examtype),
    append(Newform,Newrest,Dbform).

isonefinding(X) :-
        X = [Y|_],
        atom(Y).

ismultifinding(X) :-
        X = [Y|_],
        list(Y).

tdbformulti([],[],_,_) :- !.
tdbformulti([X|Rest],Xdblist,Examtype) :-
    todbform(X,Xdb,Examtype), % single finding or recommend
      tdbformulti(Rest,Xdbrest,Examtype),
      ( Xdb = [], Xdblist = Xdbrest;
        append([Xdb],Xdbrest,Xdblist)
      ).

todbform([Type,Finding|Mods],Xdb,Examtype) :-
    okframetype(Type),   Type \= recommend, !,
    ( computecode(Finding,finding,Medterm,Examtype),   %find medcode
      certaintychk(Mods,Cval),
      statuschk(Mods,Sval),
      %removenull(Mods,Mods1),
      fixmods(Mods,Mods1,Examtype),
      computeval(Cval,Sval,Value),
      Xdb = [Medterm,Value|Mods1];
      Xdb = []   %finding cannot go in database - no medcode
    ), !.
```

```
todbform([recommend,PuExam|Mods],Xdb,Examtype) :-
    ( computerecval(PuExam,Mods,Val,Examtype,Mods1), % compute value for recommend
      fixmods(Mods1,Mods2,Examtype),
      %removenull(Mods1,Mods2),
      Xdb = ['report recommendation item',Val|Mods2];
      Xdb = []   %finding cannot go in database - no medcode
    ), !.

todbform(_,[],_) :-!.

% compute value of finding for database
findingval(Medterm,Cval,Sval,Newmods,Xdb) :-
      computeval(Cval,Sval,Value),
      Xdb = [Medterm,Value|Newmods].

% Value of recommendation is computed as follows:
%      1. If there is an exam or procedure mentioned, that value
%         2. Otherwise, if 'follow up' is value and/or no exam is
%            is mentioned, the value will be the current exam.
%         3. Otherwise, if there is a follow up time period mentioned
%            the value will be the current exam, and it will have a
%            modifier which is follow-up times, with a value which
%            is the follow up time.
computerecval(PuExam,Mods,Val,Examtype,NewMods) :-
    certaintychk(Mods,Cval),
    degreechk(Mods,Dval),
        getspecific(PuExam,SpExam),  % get most specific exam
          % only followup is mentioned; recommend denotes followup
```

```
    (SpExam = 'followup', computecode(Examtype,_,Val,Examtype)); %code for exam
    \+ SpExam = 'followup',  %followup procedure is stated
      % value is a more specific procedure
      (computecode(SpExam,Type,Val,Examtype), Val = Examtype)
    ),
    % if there are modifiers - check time period and add approp. modifier
      addtimemod(Mods,NewMods), !.

% Get specific examination - not word followup
getspecific(FuExam,FuExam) :-
      atom(FuExam), !.
% recommend a list of exams - get most specific
getspecific(FuExam,SpExam) :-
      is_list(FuExam),
      FuExam = [Head|Tail],
      ( Head = followup, !, getspecific(Tail,SpExam), !;
        SpExam = Head
      ).

addtimemod(Mods,NewMods) :-
      futexamchk(Mods,Futval),  % get value for future exam if it exists
      Futval = [unitval,X,Timeunit],  %calculate standard time
        % This will be replace when number+unit can be stored in db
          (X = 6, Timeunit = month, FuModVal = 'follow-up in 6 months';  %6 month foll
owup      X = 6, Timeunit = week, FuModVal = 'follow-up in 6 weeks';     %6 week follo
wup       X = 1, Timeunit = year, FuModVal = 'follow-up in 1 year'),
      append(Mods,[['follow-up times',FuModVal]],NewMods), !.
addtimemod(Mods,Mods).

computecode(Regterm,Type,Medterm,Examtype) :-
    ( synonyms(Regterm,T,Medterm,Domain),  % There is a Medterm for this term
      % general domain matches any exam; otherwise Examtype must match
      ( Domain = general; Domain = Examtype; member(Examtype,Domain) ),
```

```
    ( T = Type, !;  % same type of information
      subtype(Type,T), !; % Type is a subtype of T
      member(Type,[procedure,problem,device,normalfinding,postprocedure,
                   allergy]), T = finding  %equivalent
    )
    ,
     Medterm = Regterm  % if there is no synonym, use original
    ),
     medcode(Medterm,_).   % can go into db form only if there is a medcode

certaintychk([],[]) :-!.
certaintychk([X|Rest],Val) :-
   X = [certainty,Val|_],
    certaintychk(Rest,Val).

statuschk([],[]) :- !.
statuschk([X|Rest],Val) :-
    X = [status,Val|_],
     statuschk(Rest,Val).

degreechk([],[]) :- !.
degr echk([X|Rest],Val) :-
    X = [degree,Val|_];
     degreechk(Rest,Val).

% ch ck if modifier contains a recommended time for future exam
futexamchk([],[]) :- !.
futexamchk([X|Rest],Val) :-
   X = [future_exam,Val|_];
```

```
   futexamchk(Rest,Val).

% remove empty list from present list
fixmods([],[],_) :- !.
fixmods([[]|Rest],Newrest,Examtype) :-
     fixmods(Rest,Newrest,Examtype), !.
fixmods([X|Rest],Newmods,Examtype) :-
    X = [Type,Regterm|Moremods],  % type of slot, regularized value, nested mods
    (computecode(Type,slot,Medtype,general),      % compute slot term
     computecode(Regterm,Type,Medterm,Examtype),  % compute med term
     fixmods(Moremods,NewMore,Examtype), % fix nested mods if any
    NewX = [Medtype,Medterm|NewMore];     % new controlled vocab term
    NewX = []    % no controlled term
    ),
    fixmods(Rest,Newrest,Examtype), !,
    (NewX = [], !, Newmods = Newrest;
     Newmods = [NewX|Newrest]
    ).


%computeval([],[],'moderate certainty').
computeval(Cval,Sval,Vcode) :-
   (\+ Cval = [], Vcode = Cval, !;
    Cval = [], \+ Sval = [], Vcode = Sval,!;
    Vcode = 'high certainty').

writeh17(Findings,_,Compstart,Docstart,Compend,Caller) :-
   findingtoObx(Findings,Compstart,Compend,Docstart,Caller).

findingtoObx([],Compstart,Compstart,_,_) :- !.
findingtoObx([Finding|Rest],Compstart,Compend,Docstart,Caller) :-
    writeObx(Finding,Compstart,Docstart,Compnext,Caller),
    findingtoObx(Rest,Compnext,Compend,Docstart,Caller).
```

```
writeObx([],Component,_,Component,_) :- !.
writeObx([Finding,Value|Mods],Component,Parent,Nextcomp,Caller) :-
    medcode(Finding,Code), medcode(Value,Vcode),   %Medcodes
     writeObxPart(Component),     %OBX|Component|CE|
     writecoded(Code,Finding),
     write(Parent), write('|'),
     writecoded(Vcode,Value),
     writeendObx(Caller),
     Newcomponent is Component + 1,
   % write modifier components
     writemodObx(Mods,Newcomponent,Component,Nextcomp,Caller).

% handle unit hl7
% writeObx([Finding,Value|Mods],Component,Parent,Nextcomp) :-
% handle date hl7
% writeObx([Finding,Value|Mode],Component,Parent,Nextcomp) :-

% no new component written because Medcode missing
writeObx([_|_],Component,_,Component,_) :- !.

writemodObx([],Component,_,Component,Parent,Finalcomp,Caller) :- !.
writemodObx([Mod|Rest],Component,Parent,Finalcomp,Caller) :-
     writeObx(Mod,Component,Parent,Nextcomp,Caller),
     writemodObx(Rest,Nextcomp,Parent,Finalcomp,Caller).

writeObxPart(Component) :-
     write('OBX|'), write(Component), write('|CE|').

writecoded(Code,Finding) :-
     write(Code), write('^'), write(Finding), write('|').
```

```
writeendObx :- write('||||||'), nl.
writeendObx(Caller) :- write('||||||'), new_line(Caller).
```

Claims

1. A computer method for processing medical/clinical data comprising a natural-language phrase,

the method comprising parsing the natural-language phrase and regularizing the parsed phrase,

wherein parsing comprises referring to a domain parameter whose value is indicative of a medical/clinical domain from which the data originated.

2. The method according to claim 1, further comprising preprocessing the data prior to parsing, with preprocessing comprising referring to the domain parameter.

3. The method according to claim 1, further comprising encoding at least one term of the regularized phrase, with encoding comprising referring to the domain parameter.

4. The method according to claim 1, further comprising filtering the regularized phrase.

5. The method according to claim 1, further comprising referring to an additional parameter which is indicative of the degree to which subphrase parsing is to be carried out.

6. The method according to claim 1, further comprising referring to an additional parameter which is indicative of desired filtering.

7. The method according to claim 1, further comprising referring to an additional parameter which is indicative of a desired type of output.

8. The method according to claim 1, further comprising referring to an additional parameter which is indicative of a desired output format.

9. A computer system for processing medical/clinical data comprising a natural-language phrase,

the system comprising means for parsing the natural-language phrase and means for regularizing the parsed phrase,

wherein the parsing means comprises means for referring to a domain parameter whose value is indicative of a medical/clinical domain from which the data originated.

10. The system according to claim 9, further comprising means for preprocessing the data prior to parsing, with the preprocessing means comprising means for referring to the domain parameter.

11. The system according to claim 9, further comprising means for encoding at least one term of the regularized phrase, with the encoding means comprising means for referring to the domain parameter.

12. The system according to claim 9, further comprising means for filtering the regularized phrase.

13. The system according to claim 9, further comprising means for referring to an additional parameter which is indicative of the degree to which subphrase parsing is to be carried out.

14. The system according to claim 9, further comprising means for referring to an additional parameter which is indicative of desired filtering.

15. The system according to claim 9, further comprising means for referring to an additional parameter which is indicative of a desired type of output.

16. The system according to claim 9, further comprising means for referring to an additional parameter which is indicative of a desired output format.

17. A combination of the system according to claim 9 with an interface module for enabling the system to receive input from and/or to produce standardized output for the World-Wide Web and/or a local network.

18. The combination according to claim 17, further comprising means for viewing the output using a standardized browser.

19. The combination according to claim 18, wherein the browser is a Web-browser.

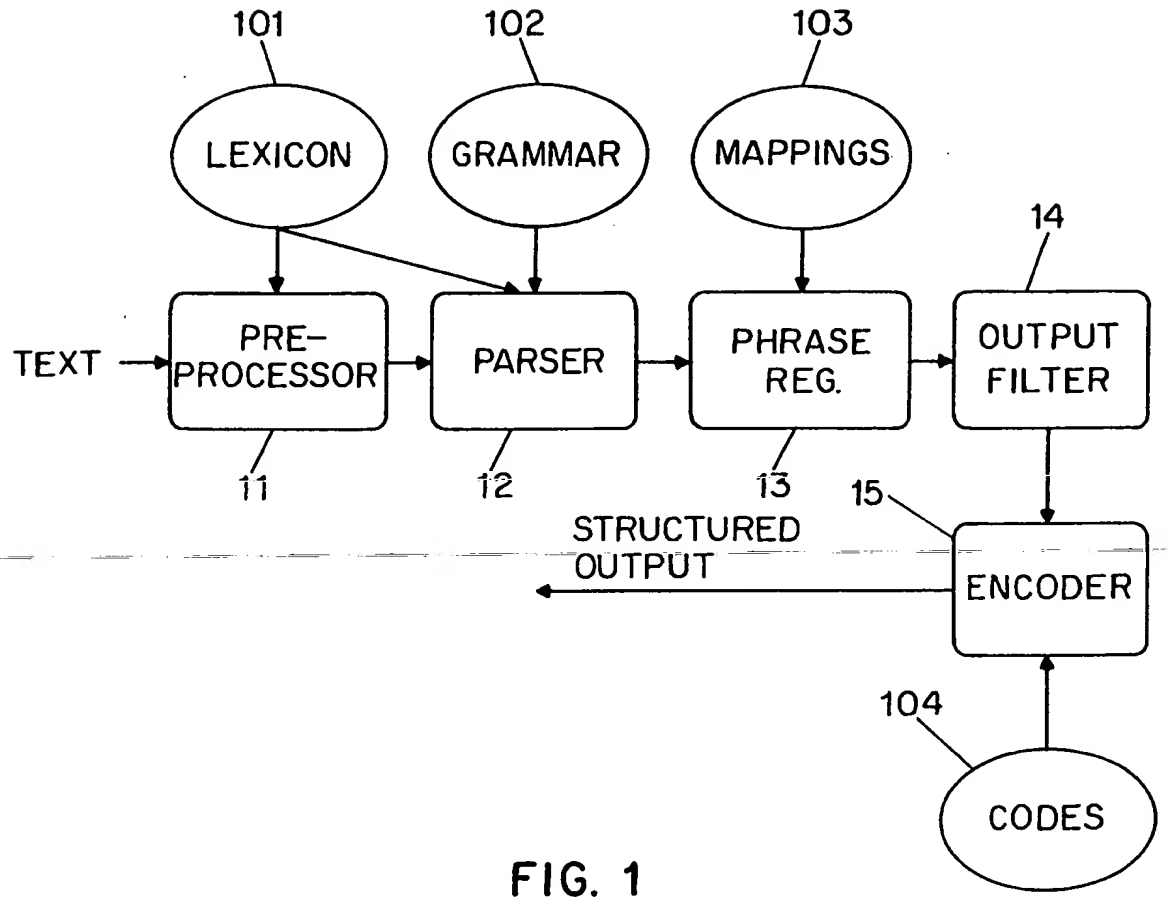

101
102
103
LEXICON
GRAMMAR
MAPPINGS
14
TEXT
PRE-PROCESSOR
PARSER
PHRASE REG.
OUTPUT FILTER
11
12
13
15
STRUCTURED OUTPUT
ENCODER
104
CODES

FIG. 1

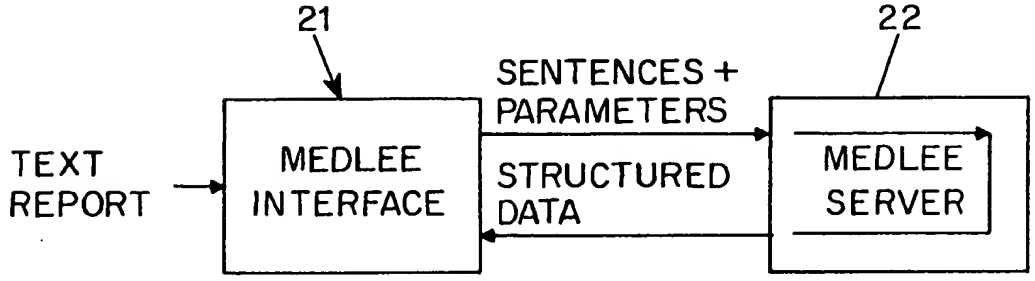

21
22
SENTENCES + PARAMETERS
TEXT REPORT
MEDLEE INTERFACE
STRUCTURED DATA
MEDLEE SERVER

FIG. 2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US97/19362

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :G06F 17/22
US CL :704/9

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 704/1, 9; 705/2, 3

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

Please See Extra Sheet.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5,377,103 A (LAMBERTI ET AL) 27 December 1994, abstract, figures 1-4; col. 3, line 26 to col. 8, line 18	1-16
A	US 5,265,065 A (TURTLE) 23 November 1993, abstract; figs.4 & 7-10; col. 1, line 9 to col. 3, line 30; col. 8, line 39 to col. 10, line 56; col. 14, line 43 to col. 18, line 33	1-16
A	US 5,251,131 A (MASAND ET AL) 05 October 1993, abstract; col. 6, line 3 to col. 7, line 64; col. 11, lines 10-67	1-16

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"B"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search 20 JANUARY 1998	Date of mailing of the international search report 06 MAR 1998
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer JOSEPH THOMAS Telephone No. (703) 308-3900

Form PCT/ISA/210 (second sheet)(July 1992)*

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US97/19362

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4,965,763 A (ZAMORA) 23 October 1990, abstract; figs. 10-18; col. 3, line 19 to col. 7, line 68; col. 30, line 27 to col. 31, line 15; col. 33, line 46 to col. 34, line 16; col. 37, line to col. 38, line 49	1-19
X ----- Y	FRIEDMAN, C. et al., "Natural Language Processing in an Operational Clinical Information System", Natural Language Engineering, Vol. 1 (1), received 15 August 1994, revised 07 March 1995, copyrighted 1995 and published by Cambridge University Press, pages 83-108, especially pages 83-97 and 104-106	1-16 --------- 17-19
Y	RUBIN, R. "Can't Reach Your Doctor? Try E-mail.", U.S. News & World Report (magazine article), 13 February 1995, pages 82-83	17-19
A	BENNAHUM, D. "Docs for Docs", Wired (magazine article); March 1995. pages 100, 102, & 104	17-19
A	EL GUEDJ, P.O. et al., "A Chart Parser to Analyze Large Medical Corpora"; Proceedings of the 16th Annual International Conference of the IEEE Engineering in Mediicne and Biology Society, IEEE, November 1994, pages 1404-1405	1-16

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US97/19362

B. FIELDS SEARCHED
Electronic data bases consulted (Name of data base and where practicable terms used):

APS

search terms: parsing, medical/clinical data, coding/encoding, natural language, domain, filtering